AP® PHYSICS
2011 SCORING GUIDELINES (Form B)

General Notes About 2011 AP Physics Scoring Guidelines

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be earned. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong, e.g., a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally earn credit. For example, if use of the equation expressing a particular concept is worth one point, and a student's solution contains the application of that equation to the problem but the student does not write the basic equation, the point is still earned. However, when students are asked to derive an expression it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the AP Physics exam equation sheet. For a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each, see "The Free-Response Sections — Student Presentation" in the *AP Physics Course Description*.

4. The scoring guidelines typically show numerical results using the value $g = 9.8\ \text{m/s}^2$, but use of $10\ \text{m/s}^2$ is also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences in rounding throughout the question typically earn full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

AP® PHYSICS B
2011 SCORING GUIDELINES (Form B)

Question 2

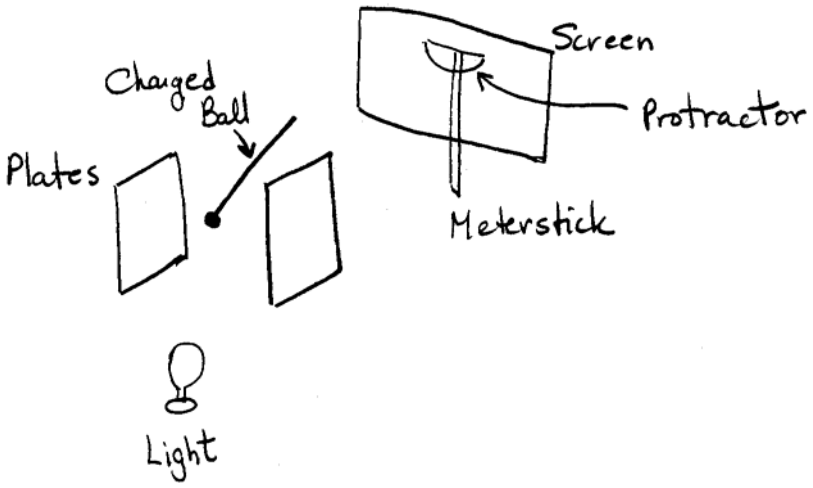
15 points total **Distribution of points**

(a) 1 point

For checking any of the equipment listed 1 point

(b) 3 points

Sample diagram



For including the plates and ball 1 point
For including all objects checked, with the exception of measurement devices 1 point
For clearly labeling each piece of equipment 1 point

(c) 6 points

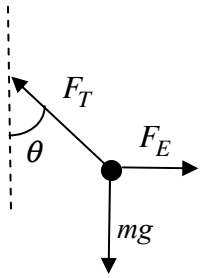
For an indication of the measurements to be taken 1 point
For indicating the equipment associated with each measurement 1 point
For using each object checked in part (a) 1 point
For clearly describing each measurement 1 point
For only including measurements relevant to determining the electric field or force 1 point
For the entire procedure being complete and correct 1 point
For example: Suspend the ball between the plates, and set up the screen perpendicular to the plates. Shine the light on the ball so the shadow falls on the screen. Using the meterstick as a vertical line, measure the angle of the string's shadow with the protractor.

Question 2 (continued)

Distribution of points

(d)

i. 3 points



For an indication of the relationship between forces that justifies the method for determining the electric field — 1 point

$\sum F_{\text{net}} = 0$

$F_T \sin\theta = F_E$ and $F_T \cos\theta = mg$

The two equations above can be used to eliminate F_T and solve for F_E.

For a correct expression for the electrostatic force — 1 point

$F_E = mg\tan\theta$

$E = F_E / q$

For an expression for the magnitude of the electric field — 1 point

$E = mg\tan\theta / q$

ii. 1 point

For correctly explaining how to determine the field direction — 1 point

For example: The force on a positive charge is in the same direction as the field. Therefore the direction of the field is in the direction of the ball's deflection.

iii. 1 point

For correctly explaining how to determine which plate is positive — 1 point

For example: The electric field is directed from positive to negative charges. Once the direction of the field is determined, you know which plate is positively charged.

2. (15 points)

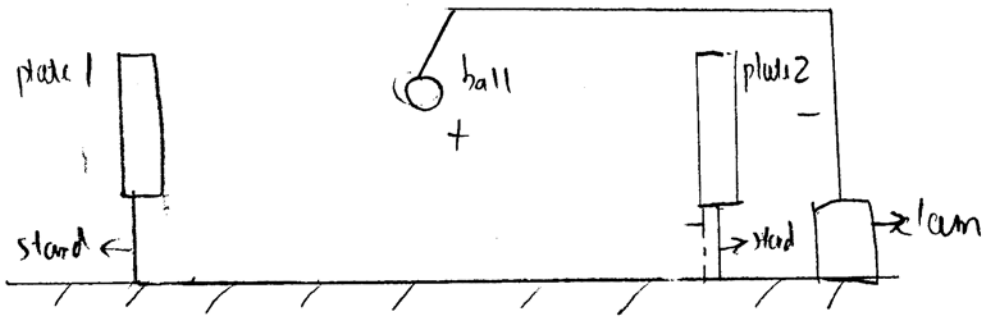
You are to determine the magnitude and direction of the electric field at a point between two large parallel conducting plates. The two plates have equal but opposite charges, but it is not known which is positive and which is negative. The plates are mounted vertically on insulating stands.

(a) A small ball of known mass m, with a small charge $+q$ of known magnitude, is provided. The ball is attached to an insulating string. The additional laboratory equipment available includes only those items listed below, plus stands and clamps as needed. Choose the equipment you would use to make measurements needed to determine the magnitude and direction of the electric field between the two plates.

$E = \frac{kq}{r^2}$

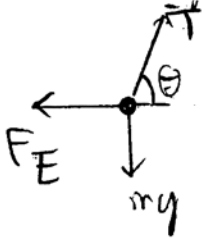
✓ Wooden meterstick	✓ Protractor	___ Screen
___ Spring scale	___ Stopwatch	___ Bright light
___ Metal rod	___ Camera (still or video)	___ Binoculars

(b) Sketch a diagram of the experimental setup and label the pieces of equipment used.



(c) Outline the experimental procedure you would use, including a list of quantities you would measure. For each quantity, identify the equipment you would use to make the measurement.

Free body diagram of the ball (assume that the ball swing to the left



$\Sigma F_y = 0$

$mg = T\sin\theta$

$\Sigma F_x = 0$

$F_E = T\cos\theta$

$Eq = T\cos\theta$

After set up the experiment, we use the protractor to measure the angle θ. Then we use the wooden meterstick to measure x and y then find θ through geometry (this is for double checking)

GO ON TO THE NEXT PAGE.

(d)

i. Explain how you would calculate the magnitude of the electric field.

$\Sigma F_y = 0$

$mg = T\sin\theta \quad (1)$

$\Sigma F_x = 0$

$Eq = T\cos\theta \quad (2)$

$\frac{(2)}{(1)} = \frac{Eq}{mg} = \cot\theta$

Since q, m_q and θ are known, we can find E

ii. Explain how you would determine the direction of the electric field.

Since the ball is positively charged, it will move in the same direction of the electric field, we just need to take note of the direction where ~~it shot~~ the ball swing.

iii. Explain how you would determine which plate is positive.

The positive plate will repel the ball since they both have positive charge. The direction of the field is from the positive plate to the negative plate From the direction found in part ii, we can also ~~find~~ find the positive plate

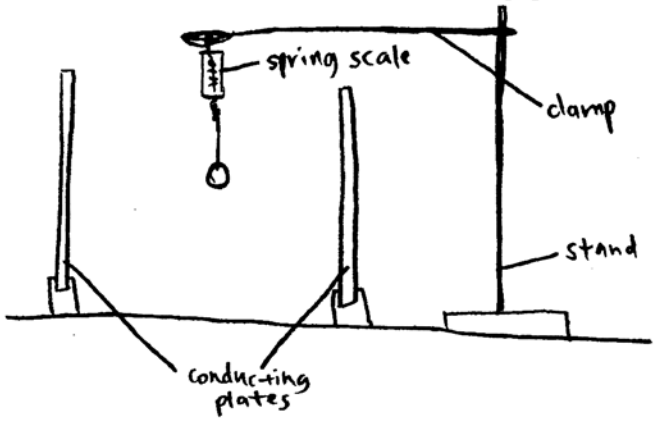
2. (15 points)

You are to determine the magnitude and direction of the electric field at a point between two large parallel conducting plates. The two plates have equal but opposite charges, but it is not known which is positive and which is negative. The plates are mounted vertically on insulating stands.

(a) A small ball of known mass m, with a small charge $+q$ of known magnitude, is provided. The ball is attached to an insulating string. The additional laboratory equipment available includes only those items listed below, plus stands and clamps as needed. Choose the equipment you would use to make measurements needed to determine the magnitude and direction of the electric field between the two plates.

✓ Wooden meterstick	✓ Protractor	____ Screen
✓ Spring scale	____ Stopwatch	____ Bright light
____ Metal rod	____ Camera (still or video)	____ Binoculars

(b) Sketch a diagram of the experimental setup and label the pieces of equipment used.



(c) Outline the experimental procedure you would use, including a list of quantities you would measure. For each quantity, identify the equipment you would use to make the measurement.

Set up the two plates facing each other a fixed distance away. Lower the ball, on a spring scale, into the middle of the plates using a stand and a clamp.

Measure the distance between ~~the two plates using the wooden meterstick~~ one metal plate and the two metal plates.

Measure the angle made by the string with the spring scale.

(d)

i. Explain how you would calculate the magnitude of the electric field.

Resolve the vectors for the force of the spring on the ball as well as the weight of the ball. The electric force the plate is exerting on the ball can then be found since the forces should all balance out. Since ~~E =~~ $E = \frac{F}{q}$, the ~~elec~~ magnitude of the electric field can be found by dividing the force by the charge of the ball.

ii. Explain how you would determine the direction of the electric field.

The direction of the electric field is the horizontal vector of the motion of the ball when it is put between the two plates.

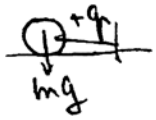
iii. Explain how you would determine which plate is positive.

The plate which the ball is attracted towards and is nearer to is negatively charged while the other is positively charged.

2. (15 points)

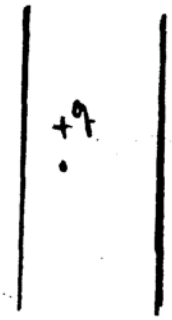
You are to determine the magnitude and direction of the electric field at a point between two large parallel conducting plates. The two plates have equal but opposite charges, but it is not known which is positive and which is negative. The plates are mounted vertically on insulating stands.

(a) A small ball of known mass m, with a small charge $+q$ of known magnitude, is provided. The ball is attached to an insulating string. The additional laboratory equipment available includes only those items listed below, plus stands and clamps as needed. Choose the equipment you would use to make measurements needed to determine the magnitude and direction of the electric field between the two plates.



____ Wooden meterstick	____ Protractor	____ Screen
____ Spring scale	✓ Stopwatch	____ Bright light
✓ Metal rod	____ Camera (still or video)	____ Binoculars

(b) Sketch a diagram of the experimental setup and label the pieces of equipment used.



$F = \frac{1}{2}kx^2$

(c) Outline the experimental procedure you would use, including a list of quantities you would measure. For each quantity, identify the equipment you would use to make the measurement.

The stop-watch is used to measure the time

The metal rod is used to measure

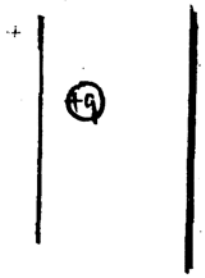
(d)

i. Explain how you would calculate the magnitude of the electric field.

∵ $E = \frac{F}{q}$. if the magnitude of the electric field can be measured like this, then we can simply calculate the magnitude of F

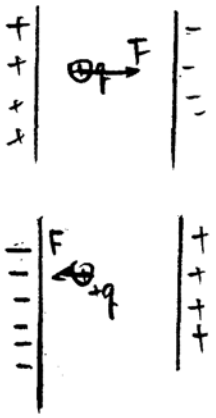
∴ $\Sigma F = ma$

ii. Explain how you would determine the direction of the electric field.



When the small ball with +q is placed in the middle, it will move due to the force of the magnetism. By counting its direction, we can use the left hand rule to determine the direction of the electric field. The thumb represents ~~the dire~~ direction of force. Far fingers : the direction of movement. Also, let the lines go through the hand.

iii. Explain how you would determine which plate is positive.



By using the left hand rule and comparing the results with the ~~graph~~ graph, we can easily indicate which plate is positive.

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AP® PHYSICS B
2011 SCORING COMMENTARY (Form B)

Question 2

Sample: B2A
Score: 15

This is a clear response with straightforward work. Note that neither the meteoritic nor the protractor needed to be included in the lab diagram.

Sample: B2B
Score: 7

Parts (a) and (b) earn full credit. Part (c) earned 1 point for indicating the measurements to be taken. The other points were not earned because the student does not always indicate which instrument to use for each measurement, some measurements are not clear (such as how one measures an angle with a spring scale), not all measurements are relevant (the distance between the plates), and the procedure is unclear and incomplete. Part (d) i earned 1 point for the correct equation. Part (d) ii is unclear and earned no credit. Part (d) iii earned full credit.

Sample: B2C
Score: 3

Part (a) earned full credit. Part (b) earned 1 point for including the ball and plates, but the diagram is vague and not labeled. Part (c) earned no credit. Part (d) i earned 1 point for the correct equation. Parts (d) ii and (d) iii earned no credit. In part (d) iii the diagram is acceptable but the explanation is incorrect, so no credit was earned.